Are we ready? Identifying the gap between academia and software industry in the context of agile methodologies

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Abstract. *Nowadays, there is an exponential increase in the technology industry. However, there is not enough movement to promote changes in the Computer Science curricula. This study aims to analyze the alignment between Brazilian northeast academia and the global industry regarding developing skills in agile methods. This research conducted an exploratory and quantitative survey with 166 participants represented by 65 students, 85 professionals from 10 countries, and 16 university professors. The preliminary results illustrate that academics believe that they are moderately aligned with the market. However, from the practitioner's viewpoint, it is unsatisfactory. This article reports relevant findings that can help the Brazilian academy align its practices with the needs of the global software industry.*

1. Introduction

Nowadays, there is an exponential increase in the technology industry. This rapid growth, aligned with the increasing demand for more robust methods for dealing with software development, has fostered the search for excellence and continuous improvement in software quality, culminating in the emergence of Agile Software Development (ASD) [Kamei *et al.* 2017, Sahin & Celikkan 2020].

In this context, studies illustrate a lack of alignment between what academia teaches and what the industry needs [Lethbridge *et al.* 2007, Von Wangenheim & Silva 2009, Moreno *et al.* 2012, Meira 2015, Barbosa *et al.* 2020]. However, promoting this connection is often lacking in university Computer Science programs and can severely hamper the growth of the software industry [Chookittikul *et al.* 2011].

The general objective of this study is to analyze the alignment between the academia (students and professors) and industry (professionals) perspectives regarding the skills and competencies needed for the IT market in the context of agile methods. The analyzed set of skills are grouped by the following topics: university approach and methods for disciplines, agile practices knowledge, soft skills, and perspective on Industry-Academia Collaboration (IAC) initiatives. To achieve this, specific goals are addressed: i) Identify the expected skills from the IT professionals in the IT market; ii) Identify the correlation between what is promoted by teachers, the skills learned by IT students at Higher Education Institutions(HEIs), and the market demands; iii) Identify the correlation between agile methods and agile practices required from IT professionals; and, (iv) Identify stakeholders' views regarding IAC initiatives.

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2. Background

The global software industry requires continuous improvement to remain competitive and respond to fast growth without losing software quality. In response to these constant changes, agile methods represent a notable solution widely used nowadays [Kamei *et al.* 2017]. The use of agile methods is a successful approach to developing software due to flexibility and low effort to maintain and emphasizes high quality and speed of development [Chookittikul *et al.* 2011].

Software academia plays an important role in the global business community since computer science undergraduate programs provide the knowledge and foundation skills for technological innovations. Also, students will become practitioners after graduation, and they need to be prepared for the high standards of the global software community. However, there is a gap between information technology (IT) education and industry [Chookittikul *et al.* 2011]. In this research, we found several studies reporting evidence of the lack of significant changes in the traditional computer science curricula [Chookittikul & Chookittikul 2008, Shaw *et al.* 2005, Norman & Venter 2017, Tuzun *et al.* 2018, Kuhrmann *et al.* 2019, Macêdo *et al.* 2020].

Garousi *et al.* highlight that besides the software industry and software academia having the same goals, there is a low collaboration between them [Garousi *et al.* 2016]. The best way to ensure this demand is achieved is to require that industry and academia collaborate to design course curricula and update them regularly [Chookittikul *et al.* 2011]. That way, Chookittikul *et al*. propose a combined approach with theory and practice is included, providing real-world problems and practical skills to computer science programs. This could potentially improve student engagement, and better prepare them for the industry.

2.1. Related Work

Chookittikul *et al*. in their research highlighted that academia was not aligned with industry needs [Chookittikul & Chookittikul 2008]. This research claims that academia should always guarantee the continuous quality improvement of the programs to ensure that students meet the demands of the employers. Later, Chookittikul *et al*. investigate the gap between academia and industry in Vietnam [Maher *et al.* 2010] and Thailand [Chookittikul *et al.* 2011]. Both studies analyze the adoption of agile methodologies in the industry and the gap in academia to update their curricula to meet constant market changes. This study was used as reference for this research.

Garousi *et al*. conducted a Systematic Literature Review and collected evidence of 101 projects from 21 countries in an empirical study to characterize the industrial needs. Their study contributes to the body of literature for IAC and suggests that lack of commitment is one of the biggest challenges in projects [Garousi *et al.* 2019].

Sahin *et al*. made a similar study on the gaps in higher educational institutions and the software industry. This research focused on the required skills that IT professionals need and how the education institutions are preparing them. This study involved an online survey for 64 universities, 38 companies. In total were 209 participants (99 professionals, 72 academics, and 38 employers). This study has a global version of 24 countries and it differentiates from ours because we collect evidence only for Brazilian students [Sahin & Celikkan 2020].

3. Methods

The present study is characterized by its multi-method approach that combines two or, more quantitative and/or, qualitative methods [Hesse-Biber 2010], since it promotes the replication of survey researches carried out in four other base studies. In summary, this research characterizes its objective as exploratory, the approach as quantitative, and the methodological procedure is characterized as survey, which according to [Blumberg *et al.* 2008] is an appropriate measurement process for gathering information in a highly structured interview. It generally makes use of the quantitative methodology, for instance, in the study of a given population, the interview makes it possible to infer conclusions about its people through observations of a small sample of this population [Rouse 1997]. In the current study's case, it is sought to correlate the variables from the triangulation of the data collected in the survey research.

3.1 Research's Scope: This study focused on three stakeholder profiles: Brazilian IT industry professionals (local and global market), IT undergrad students (local), and IT professors (local). In this study context local means northeast of Brazil, specifically the Metropolitan region of Recife (MRR), where Porto Digital is located, one of the national biggest technology centers. To analyze the needs of professional training in the region and compare them with the necessity of the global market, in addition, the study covers aspects of local academic studies, conducting survey researches with Higher Education Institutions (HEIs) in the metropolis focusing on raising information about the skills that are taught by Software Engineering teachers and which ones are learned by the students, regarding especially Agile Methods. It is also noteworthy that the study was carried out from March to May 2021.

3.2 Methodological Procedures: The adopted methodological procedures were surveys based on the replication of four other opinion surveys: 1) Maher; Kourik e Chookittikul [Maher *et al.* 2010], who conducted a survey with Developers, Project Managers and IT Managers in Vietnam; 2) Chookittikul; Kourik and Maher [Chookittikul *et al.* 2011] who surveyed Developers and IT Managers from Thailand; 3) Sahin [Sahin & Celikkan 2020], who conduct a survey to understand the IT skills gaps and 4) Portela [Portela *et al.* 2017] that applied a survey with professors and students of SE, based on the documentary analysis of the reference curriculum of ACM/IEE and SBC.

Considering what has been exposed, the findings will be triangulated to refute or, consolidate the results of the base studies in the context of Brazilian graduates, since the collection of data from several different sources helps reinforcing the study's validity [Easterbrook *et al.* 2008, Evanschitzky *et al.* 2007].

It is noteworthy that replication is vital to scientific progress, as it allows observing, investigating, experimenting, comparing results, validating, and clearly defining theories [Morrison *et al.* 2010, Berthon *et al.* 2002]. Specifically, in the case of surveys, their value is higher if the replications allow the reader to expand the inferences and generalizations. These surveys are based on meta-analyses, which, in turn, are supported by high-quality replicated studies [Eden 2002, Hubbard *et al.* 1998]. In this analysis, the replication process is categorized in the literature in several ways, such as the typologies proposed by [Easley *et al.* 2000]: type i - a faithful copy of the original research; type ii - an approximate copy of the original research; type iii - deliberate alteration of the original research.

Thus, the present research is characterized as type iii replication. This type can presents modification concerning the base research, which can be methodological and/or, conceptual [Easley *et al.* 2000]; We propose in the present study in which methodological and conceptual changes were made to give greater strength to the study, through a meta-analysis developed to combine independent studies, focused on a single issue, carrying out a "study of studies" [Morrison *et al.* 2010, Hunter 2001]. Initially, a graphical analysis of the data was carried out through the generation of the histograms, and it was observed that the data set has a normal distribution. And, to confirm this finding, their descriptive statistics were performed, through the analysis of mean, fashion, median, asymmetry, and kurtosis, which confirmed the findings of the graphic analysis.

The correlation matrix was elaborated using the statistical software SPSS, and to determine if the correlation between the variables is significant, its level of significance was observed (p). In general, a significance level of 0.05 works well, which indicates that the risk of concluding that a correlation exists when, in fact, no correlation exists, is 5%. In this study, the significance of 0.05 and 0.01 were considered.

Pearson's Linear Correlation coefficient (r) is a measure ranging from –1 to +1. The coefficient provides information on the type of association of variables through the sign so that if r is positive, there is a direct relationship between variables, if r is negative, there is an inverse relationship between variables and if r is null or, approximately null, it means that there is no linear correlation. According to Franzblau [Franzblau 1958] the correlation coefficient can be interpreted as follows: Negligible correlation: until 0.20; Weak correlation: between 0.20 and 0.40; Moderate correlation: between 0.40 and 0.60; Strong correlation: between 0.60 and 0.80; Very strong correlation: bigger than 0.80. Therefore, to interpret this coefficient, it was decided to consider only the moderate, strong, and very strong correlations in the analyzes.

3.3 Data collection instruments: The data collection instrument used was an online structured questionnaire (available at https://forms.gle/zXhQeAFzYp3DSaqZ6). Participants from the IT field with different profiles were randomly selected and a survey was sent to them via email and other social media platforms.

For each participant group one questionnaire was designed with 5 sessions: *Session 1:* Explaining the purpose of the study and asking for a confidentiality agreement. Participants are not identified as individuals because it was not relevant for our study and it helps to guarantee veracity on answers. *Session 2:* This changes for each group but aims to understand specific group view regarding university curricula for IT courses in Brazil [Portela *et al.* 2017, Sahin & Celikkan 2020]; *Session 3:* This session was elaborated to validate IT industry skills competencies that graduates have/need when they enroll in the IT local and global market. This session covers ADS technical skills [Dybå & Dingsøyr 2008, Maher *et al.* 2010] but also non-technical (such as soft skills); *Session 4:* This session was designed to understand the view of the stakeholders regarding the relevance of Industry-Academia Collaboration (IAC) and also which type of initiative is considered adequate [Chookittikul *et al.* 2011]; *Session 5:* Covers demographic questions.

4. RESULTS AND DISCUSSIONS

In this survey study, 166 participants represented 65 students from 4 different undergraduate courses, 85 professionals from 51 companies (10 countries), and 16 professors from the public (25%), private (31.25%), or, both (43.75%) universities. The majority of professionals are working on the global market (48,8%) and the other half are on the local (27,5%) and national market (23,8%). Most of the professors and professionals are in the same age range (30-39) meanwhile students are mostly in their twenties (20-29).

4.1. Research Question (RQ) 1: What are the skills that the market expects from IT professionals?

Survey results show the relevance of skills for the IT market. In the Table 1, can be observed that all interviewed profiles consider communication, teamwork, conflict resolution, interpersonal relationship, and analytical thinking as the most important skills for IT professionals.

Table 1. RQ1: Skills expected from IT professionals

	Median	SD
Team work	95.45%	4.05
Communication	94.87%	10.42
Analytical thinking	87.18%	12.97
Conflict resolution	76.92%	15.37
Interpersonal relationship	74.36%	12.37
Emotional intelligence	69.23%	9.91
Leadership	59.09%	16.56
Management	54.55%	16.11
Customer relationship	53.85%	22.77
Interlocution skills	47.37%	8.77
Negotiation	41.03%	10.11
Entrepreneurship	31.82%	12.13
Proactivity and ownership	0.00%	1.15
Continuous growth mindset	0.00%	2.35
Technical knowledge and willingness to learn	0.00%	2.03
Empathy	0.00%	2.35
None	0.00%	1.98

When the results are analyzed grouped by profiles, we have some different perspectives. It is observed that 100% of professors emphasize communication and teamwork. The majority (87,5%) of professors also believe in emotional intelligence and customer relationship as important skills. For students, over 90% attach importance to teamwork, a skill most highlighted by this profile. Also, more than 76,92% point out customer relationships and analytical thinking as relevant skills. IT professional's results show that teamwork is considered a fundamental skill (100%), followed by analytical thinking with just over 90%. After that, above 68,29% include analytical thinking and interpersonal relationship. Also, some skills were not considered by the analyzed profiles, notably entrepreneurship proved to be an irrelevant skill in the perspective of professors and students, added to this in the perception of undergraduates, it was observed that skills such as negotiation and interlocution skills are also not considered important for that profile. Finally, about IT professionals, no importance is attached to negotiation skills.

4.2. RQ2: Which are the perspectives from teachers, students and IT professionals about skills promoted by HEIs?

Results show that professors consider communication, teamwork, analytical thinking, and management as the most important ones. However, among students, teamwork, analytical thinking, and communication were the most voted ones. Also, for professionals, analytical thinking was chosen followed by teamwork. Besides, local and global professionals also highlighted management meanwhile national professionals voted more for communication. This illustrates, that there is a lack of consensus between what is taught and what is learned, whether they are currently graduating or, already professionals. So, the only consensus that exists is regarding the ability of analytical thinking pointed out by the three professional profiles as a skill learned in the local academy, although in the teaching and graduate profiles this ability does not appear prominently, which may denote that there has been a change to skills taught in the academy since the training of professionals 10 years ago.

Among the skills taught by academia, it was observed in Table 2 that only emotional intelligence has a strong correlation with the skill learned by the students, which indicates that both profiles have the same perception regarding the development of this skill in the academy. Only the leadership skill showed a inverse strong correlation between the profile of professors and professionals in the global industry, and only the management skill showed a moderate correlation between the profile of students and professionals in the local industry. This indicates again a low alignment between what is taught and learned.

Table 2. RQ2 - Skills promoted by HEIs

Skills	r	p	n
Leadership (Pl—Pfg)	-0.620	0.01	16
Emotional intelligence (Pl—Sl)	0.620	0.01	16
Management (Sl—Pfl)	0.455	0.034	22
Interpersonal relationship (Pfl—Pfg)	0.505	0.016	22
Interlocution (Pfl—Pfn)	0.544	0.016	19
Interlocution (Pfl—Pfg)	0.549	0.008	22

P: Professors — S: Students — Pf: Professionals
g: Global — l: Local — n: National
r: correlation — p: significance — n: quantity

4.3. RQ3: What are the perspectives from stakeholders regarding agile methods and agile practices required from IT professionals?

Through the correlation analysis on Table 3, it can be observed that among the agile methods taught by the local academy, only the Feature-Driven Development (FDD) method presents a moderate correlation with the national and global industry professionals. However, this does not configure as the method most disseminated in the academy by professors. The Scrum method, highlighted by professors and graduate profiles, has a moderate correlation with professionals in the global industry. Finally, it is observed that there is a moderate correlation between the profiles of national and global industry professionals regarding the eXtreme Programming (XP) method. In summary, it can be inferred that there is low alignment between the agile methods taught and learned in the local academy and the industry.

Table 3. RQ3 - Agile methods and practices promoted by HEIs

Skills	r	p	n
FDD (Pl—Pfn)	0.590	0.016	16
FDD (Pl—Pfg)	0.537	0.032	16
Scrum (Sl—Pfg)	0.480	0.002	39
XP (Pfn—Pfg)	0.548	0.015	19
Whole Team (Pl—Pfl)	0.590	0.016	16
Unit Testing (Pl—Sl)	0.595	0.015	16
Sustainable Pace (Pl—Pfg)	0.590	0.016	16
Refactoring (Sl—Pfl)	0.451	0.035	22
Coding Standards (Sl—Pfn)	-0.510	0.026	19
Continuous Integration (Pfl—Pfn)	-0.472	0.041	19
None (Pfl—Pfn)	0.544	0.016	19

P: Professors — S: Students — Pf: Professionals
g: Global — l: Local — n: National
r: correlation — p: significance — n: quantity

4.4. RQ4: What is the view of stakeholders regarding IAC?

All the analyzed profiles consider the IAC to be relevant for achieving the fit between what is taught and the needs of the IT industry. Among the types of collaboration analyzed to promote the alignment between industry and academia, the real-world research project is the first alternative most cited by professors and professionals in the local industry and the second most cited by other profiles. The internship is the type of IAC most cited by students and professionals in the national and global industry, and the second most cited by professionals in the local industry. Educational Hub Initiative and Events like hackathons are the most cited by teachers, the latter being the third most cited by national and global professionals, as well as workshops. Finally, it is observed that there is a tendency of the local academy and industry for Agile development course as a type of IAC to promote alignment between industry and academy, being the third most cited by the three local profiles.

4.5. RQ5: Do the academy curricula meet the required skills from the IT market?

Considering a Likert scale of five points (where one is irrelevant and five is relevant), it was observed that professors and students are more satisfied than the professionals regarding the adequacy between both communities. Table 4 shows that professors and students, the mean value for IT industry is slightly higher than three, which indicates a moderate alignment, however, for IT professionals this adequacy is slightly lower, which shows that in their perspective, the alignment between academic background and market is still unsatisfactory.

Table 4. Adequacy graduates and industry

Values	Professors	Students	Local Professionals	National Professionals	Global Professionals
Mean	3.56	3.34	2.77	2.47	2.87
SD	1.153	1.215	1.020	0.697	0.732
N	16	65	22	19	39

4.6. DISCUSSION

Dyba's (2008) research results highlight that there is a lot of studies regarding XP methodologies but other agile methodologies are still not being properly covered by academia. Our results show that scrum has being more popular in the industry and also at the HEIs. Despite that, there is still a lack of propagation of others methodologies.Also, regarding agile practices promoted by academia, our findings show that professors, students and market professionals have totally different views and priorities [Dybå & Dingsøyr 2008].

Table 5 illustrates our findings on the local academia and the global IT industry. The first two columns show the lack of alignment between professors and students. Also, when comparing these results with Chookittikul (2011) and Maher (2010) it can be observed that there is a lack of consensus for both communities' (industry and academia) perspectives. According to the original studies, ([Chookittikul *et al.* 2011, Maher *et al.* 2010]) academia should concentrate its effort on small releases, acceptance testing, and coding standards. Besides the agreement on small releases (with the professors) and code standards (with students), in general, they are out of sync in the priorities. Professors are more concerned about pair programming and refactoring and students value more unit testing, code standards, and pair programming.

Table 5. Agile practices - Academia vs Industry

Practices	Professors	Students	Industry*
Coding standards	37.50%	36.92%	95.00%
Small releases	68.75%	23.08%	100.00%
Pair programming	81.25%	32.31%	0.00%
Collective code ownership	50.00%	23.08%	8.00%
Refactoring	68.75%	24.62%	10.00%
Sustainable pace	18.75%	9.23%	80.00%
Acceptance testing	50.00%	23.08%	100.00%
Unit testing.	56.25%	36.92%	75.00%
Whole team	18.75%	15.38%	50.00%

*[Maher *et al.* 2010] [Chookittikul *et al.* 2011]

The present study shows on Table 6 that most teachers have as reference curriculum SBC(62.5%) and DCN (50%). However Portela's study (2017) only 24% adopted the SBC curriculum. This disparity can be explained by the sample composition since our study was based on the Brazilian northeast academy, while the Portela study had a sample from teachers all over the national territory. It is noteworthy that DCN was not an option for the study by Portela (2017) nor does it appear as an option placed by respondents in others.

As for the teaching approach adopted by the teachers, it is observed in Table 7 that both nationally as the study by Portela (2017) and locally as the findings of this study point out, the lecture classes are predominant in the perspective of the teachers, representing the equivalent to 100% of the classes. However, when considering the students 'perspective, the percentage drops to 38.5%, with students' perceptions of software design approaches and discussion of practical cases showing a percentage of 70.8% and 86,2%, respectively. These two approaches also present a high percentage considering the national academy investigated by Portela (2017) and have a respective percentage of 86% and 90%. Considering the local context adopted in this study, the percentage of teachers who adopt the

Table 6. Curriculum references comparisons

References	Professors	Portela (2017)
SBC	62.5% (10)	24%
Guidelines da ACM/IEE	18.8% (3)	16%
Others	31.3% (5)	12%
DCN	50% (8)	-

Table 7. Teaching approaches comparisons

Teaching approaches	Professors	Students	Portela (2017)
Expositive classes	38.5% (25)	100% (16)	100%
Discussion of case studies	70.8% (46)	68.8% (11)	90%
Software design	86.2% (56)	87.5% (14)	86%
Laboratory classes	60% (39)	50% (8)	71%
Use of analogies	53.8% (35)	56.3% (9)	57%
Group dynamics	63.1% (41)	68.8% (11)	52%
Games	23.1% (15)	31.3% (5)	29%
Others	-	-	14%

software design approach goes to 87.5% and the discussion of practical cases goes to 68.8%, the same percentage of group dynamics. It is noteworthy, the low percentage in the gamification approach both in the present study and in that of Portela (2017), which presents the percentage of 31.3% and 29%, respectively [Portela *et al.* 2017].

In the analysis of the evaluation strategies, there is a trend towards the development of practical and expository works from the perspective of professors from the national and local academy, and from local students. In addition to the delivery of work products and more traditional strategies such as individual tests, they are still very common in the Brazilian academy.

This scenario leads us to consider that the wide use of methods focused on the teacher, the said traditional methods according to Portela (2017) contribute to the low alignment between academia and industry since these methods fail to demonstrate the complexity of the dynamics of the software market.

Sahin (2020) findings relate to the lack of emphasis on personal and non-technical skills in undergraduate education. Comparing their results with the current study indicates that not technical skills should be promoted, and also, students should be more involved in hands-on projects, with a more complex environment and emerging software methodologies such as agile and scrum development. In summary, education should be updated regularly to provide learning experiences in the industry trends. That way, the current research confirms their finds on the Brazilian community [Sahin & Celikkan 2020].

4.7. Threats to Validity and Limitations

This section discusses some of the potential threats to this study's validity and some actions taken to mitigate them.

Construction validity: First, to avoid bias during the survey and thus compromise our data collection, all questions were divided into sessions and organized to avoid one question influencing the next question's answer. Second, we defined that our interviewees are all Brazilians (even those on the global market) to guarantee that they had their stud-

ies in Brazilian academia. Also, to foster diversity, we collected data from participants playing different roles.

Internal validity: The generality of the results, since we used a small sample in our survey that covers only the participants from Northeastern Brazilian universities (for students and professors profiles), cannot cover the perceptions of the academy's participants or, the national academia perception. However, there is a plan to expand this research to all Brazilian regions.

External validity: This study aims to validate a specific context regarding the vision for higher education institutions in Brazil. We found similar studies [Sahin & Celikkan 2020] that also performed surveys to understand the gap between higher education institutions and global software marketing. We have not compared our preliminary results with this study to avoid hasty generalizations.

5. Conclusion

The alignment between industry and academia is crucial for developing the Software Industry, whether at the local or, global level. Despite this, there are still many gaps that need to be considered and require greater collaboration to ensure such alignment, especially about the agile methods that have gained strength in recent years in the aforementioned market. Because of this, this study presented the results of a survey carried out at the Brazilian academy with professors and students of the northeast of Brazil and with Brazilian professionals who work locally, nationally, and globally to identify the gaps between each of these profiles. The main objective of the research was to analyze the alignment between Brazilian academia and global industry regarding the development of skills in the context of agile methods.

The main findings were: 1) Academia and industry have a similar view regarding the skills that are required from IT professionals. However, 2) there is a mismatch regarding what is taught by professors and learned (by students and consequently later on professionals). which may denote that there has been an update on this matter in the last 10 years. 3) Besides the propagation on the industry regarding agile methods and practices, there is still a lack of alignment from the academic side. Is worth mention that inside academia community professors and students had different views about the relevance of agile practices. 4) All profiles interviewed consider IAC relevant for them. On the local views, agile courses are the most common initiative for that. Although, the internship was the most cited of all profiles. 5) It was observed that in general, the academic community is more satisfied with their adequacy to the IT market than the industry community. 6) Also, results show that the Brazilian academic community still focused on methodologies centered on the professors instead of promoting more student-centered approaches. In that way, academia fails to foster complex environments for the students to be more prepared for the industry. This article reports relevant findings that can help the Brazilian academy to align its practices with the needs of the global software industry.

As future work, we intend to adopt a more robust sample considering the academy at a national level, as well as to triangulate the findings with the documentary analysis of the adopted curricula to identify whether they offer support to promote the alignment between the academy and the industry. Another interesting approach would be to carry out a case study on IAC projects.

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